AMOUNT AND MINERAL NUTRIENT CONTENT OF FRESHLY FALLEN NEEDLE LITTER OF SOME NORTHEASTERN CONIFERS[1]

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IN a previous paper (7)[3] the writer presented some data on the amount and mineral nutrient content of freshly fallen leaf litter of northeastern hardwood forests. This paper presents similar data for seven common northeastern conifers.

Data on the annual production of coniferous litter are not plentiful in the literature. Jenny (11) quotes a figure for Scotch pine, as given by Ebermayer, of 1.42 tons per acre. Lunt[4] gives a figure for white pine in Connecticut of 1.78 tons per acre. Alway and Zon (2) have shown that the Jack, Norway, and white pine forests of Minnesota deposit about 0.87 ton of needle litter per acre annually. These data show considerable variability and as will be pointed out later, a definite figure cannot be arrived at which will apply to all conditions.

Data on the mineral nutrient content of coniferous needle litter are not numerous, but comparisons between our data and those obtained by other workers will be made along with the presentation of the results.

EXPERIMENTAL METHODS

SELECTION OF SAMPLING AREAS

Because the conifers of the northeastern United States do not occur in pure stands over any large areas, considerable care was used in selecting the sites for obtaining samples.

Data for three of the species were secured near Ithaca, N. Y., and because this is primarily a hardwood region, all the samples were secured from beneath plantations which were about 24 years old. The species included were white pine (*Pinus strobus* L.), red pine (*Pinus resinosa* Ait.), and Norway spruce (*Picea abies* (L.) Karst.)

The other samples were all secured in the central Adirondack region in the towns of Long Lake and Newcomb. All were from natural stands where groups of trees composed of one species occurred. The species included in this locality were white pine (*Pinus strobus* L.), red spruce (*Picea rubens* Sarg.), hemlock, (*Tsuga canadensis* (L.) Carr.), white cedar (*Thuja occidentalis* L.), and balsam fir (*Abies balsamea* (L.) Mill.).

The age of these natural stands varied considerably. The balsam fir, red pine, and Norway spruce stands were the youngest, being about 25 years old. The white cedar and white pine stands averaged about 65 years of age and the red spruce and hemlock stands were over 150 years old. It is probably somewhat unfortunate that such a spread in age occurred, but it was extremely difficult to locate pure stands of these species in large enough groups to eliminate contamination of the litter by other species. Hence, age had to be considered as a secondary matter when selecting the sites.

The three plantations near Ithaca, N. Y., were all on Dunkirk silty clay loam a gray-brown podzolic soil (10). Those in the Adirondacks were on Beckett sandy loam, an acid podzol developed from syenites, granites and gneisses. The white pine samples were secured from both soil types to determine what influence soil and climate might have on the chemical composition of the litter.

METHOD OF OBTAINING LITTER SAMPLES

Because the evergreen trees do not deposit their foliage on the ground at any one period, the method of sampling is not as simple as in the case of the hardwoods. The method used consisted of placing a piece of burlap cloth about 4 feet square under the trees. This was pegged down to prevent blowing away. Four cloths were placed at random under each stand. The installations were made on May 15, 1942. At various intervals the litter that had fallen was collected from a definite portion of each burlap cloth. The area sampled was 2.17 square feet per cloth, determined by placing a barrel hoop of that area over each cloth at the sampling time. After each sampling period all of the needles were brushed off the burlap so that no old needles would be included in the next sample. Samples were collected on July 1, Aug. 20, and Oct. 3 of 1942 and the final samples were collected on May 27, 1943.

METHODS OF CHEMICAL ANALYSIS

After each collection the litter samples were oven-dried at 70°C and weighed. They were then ground in a hammer mill so as to pass through a 60-mesh sieve. All chemical analysis results were expressed as percentage of oven-dry material.

Two-gram samples were ashed over night at 450°C. The ash was taken up with 2N HCl, and after silica dehydration and removal and the removal of iron and aluminum, the filtrate was used for the determination of calcium, magnesium, potassium, and phosphorus.

Calcium was determined by the usual oxalate precipitation and titration with potassium permanganate. Magnesium was determined on the calcium filtrates by precipitation with 8-hydroxyquinoline. Potassium was determined by precipitation as potassium cobaltinitrite and titration with potassium permanganate. Phosphorus was determined by the Fiske and Subbarow method (9). Total nitrogen was determined by the standard Kjeldahl-Gunning procedure.

The analyses were originally run on all samples, but it was found that no significant differences occurred for samples of the same species collected at different times, and only the average values for the whole year are presented.

EXPERIMENTAL RESULTS

AMOUNT OF FRESHLY FALLEN LITTER

The amounts of freshly fallen needle litter for the different species are reported in Table 1.

An interesting fact revealed by the data in Table 1 is that the amount of foliage being deposited from May 15 to Aug. 20 is relatively small as compared to that which falls during the autumn and winter. It seems evident that, although the conifers do drop their needles during the entire year, the greatest fall occurs along with that of the deciduous trees. This condition is most fully expressed in the case of white cedar. It is unfortunate that a second sample was not obtained in the late autumn.

The total annual litter-fall for the various species covers the range reported in the literature. The relatively low values for red spruce and hemlock probably should be attributed to the advanced age and low vigor of the stands rather than to any influence of species. The other values ranging from 2,009 to 3,367 pounds per acre per year seem rather typical of healthy, vigorous stands.

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[3]Figures in parenthesis refer to "Literature Cited", p. 411.

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TABLE 1.—*Amounts of coniferous needle litter in pounds per acre of oven-dry material.*

Date	White pine*	White pine†	Red spruce	Hemlock	Red pine	Norway spruce	White cedar	Balsam fir
July 1, 1942‡	232.0	181.0	312.0	143.8	71.8	186.8	None fell	198.0
Aug. 20, 1942	209.8	88.3	364.3	223.0	59.6	188.8	None fell	90.5
Oct. 3, 1942	1,064.0	1,930.0	53.00	648.3	1,720.0	1,540.0	391.5	1,125.0
May 27, 1943	1,226.0	431.1	463.8	298.2	1,516.0	1,545.0	1,618.0	1,157.0
Total annual deposition	2,731.8	2,730.4	1,670.1	1,313.3	3,367.4	3,360.6	2,009.5	2,570.5

*From Ithaca.
†From Adirondacks.
‡The figures for July 1 represent litter that fell between May 15 and July 1.

Data on the mineral nutrient content of the litter are presented in Table 2.

As has been consistently reported in the literature (1, 4, 6, 7, 8, 15) more variability occurred with respect to calcium than any other macro-nutrient. The calcium content varied from 0.58% in the case of red pine to 2.16% in the case of white cedar. The increase is about 278%. The percentage increase of the highest over the lowest value for the different elements are as follows: K, 225; P, 160; N, 108; Mg, 64.

As has been shown for the hardwoods (7), the calcium content of the foliage of the conifers is related to the species rather than to the soil on which the trees are growing. This fact is supported by the close agreement in the figures for white pine growing on the coarse-textured, acid soil of the Adirondacks and the same species growing on the fine-textured Dunkirk soil near Ithaca, which has a much higher pH and free calcium carbonate in the subsoil. It is further supported by the similarity between these figures and those reported for the same species by other workers. For example, Alway and Zon (2) show that red pine litter in Minnesota has an average calcium content of 0.44%. Other data presented by Alway, Kittredge, and Methley (1), Chandler (6), and Plice (16) show some variability, but when averaged give a mean calcium content for red spruce litter of 0.60%.

White pine consistently appears to be similar to red pine, but somewhat higher. The average figure as given by the above-mentioned authors is 0.91% as compared to 0.60% presented here.

It is noteworthy that balsam fir foliage has a higher calcium content than the pines, hemlock, or red spruce. Plice (16) found this same relationship and Bodman (3) reports that white fir in California (*Abies concolor* (Gord.) Engelm.) had a higher calcium content in its litter than did Ponderosa pine (*Pinus ponderosa* Dougl.).

The high figure for Norway spruce (1.96%) seems to be out of line with the native spruces, but the writer believes that the high calcium content of Norway spruce can now be accepted as fact. Plice (16) gives a figure of 1.63% calcium. Chandler (6), using different material has presented a value of 1.60%. This does not mean that this species is particularly beneficial to the soil. In fact Plice has shown that, although the calcium content of the litter is high, the antacid buffering capacity is low and the acidity is strong.

White cedar very definitely has a high calcium content. Plice (16) reported a value of 2.55% and Chandler (6) has given one of 2.48%. These are both slightly higher than the average for this work of 2.16%.

The magnesium contents are all low, and need no further discussion here.

The potassium contents vary from 0.12% to 0.39%. Alway, Kittredge, and Methley (1) indicate a value for the potassium content of red pine of 0.26% and one for white pine of 0.18%.

The phosphorus content of the litter of the various species is low, ranging from 0.04 to 0.10%. The values seem typical of those reported in the literature. Alway, Kittredge, and Methley report values for white and red pine of 0.07 and 0.06%, respectively.

The nitrogen contents range from 0.60 to 1.25. The Minnesota values (1) for white and red pine are 0.64 and 0.67%, respectively, and are only slightly lower than our results for the same species.

TABLE 2.—*Mineral nutrient content of freshly fallen litter, expressed as percentage of oven-dry weight.*

Species	Ca %	Mg %	K %	P %	N %
Red pine	0.58	0.18	0.35	0.07	0.69
White pine*	0.60	0.16	0.18	0.05	1.14
White pine†	0.60	0.21	0.18	0.07	1.00
Hemlock	0.68	0.14	0.27	0.07	1.05
Red spruce	0.79	0.20	0.35	0.10	0.89
Balsam fir	1.12	0.16	0.12	0.09	1.25
Norway spruce	1.96	0.23	0.39	0.09	1.02
White cedar	2.16	0.15	0.25	0.04	0.60

*From Adirondacks.
†From Ithaca.

AMOUNT OF VARIOUS NUTRIENTS RETURNED TO THE SOIL

By multiplying the total amount of litter deposited each year as reported in Table 1 by the nutrient contents reported in Table 2, one can calculate the pounds per acre of nutrients returned to the soil annually. These data are reported in Table 3.

Norway spruce, white cedar, and balsam fir are conspicuous because of the high amount of calcium returned to the soil, and Norway spruce, balsam fir, and white pine deposit large amounts of nitrogen.

The average figures for all species show that much higher amounts of calcium and nitrogen are deposited than is the case with the other nutrients studied. It is interesting to compare these data with those for the hardwood species (7). The amount of nitrogen deposited is somewhat higher than in the case of the hardwoods (23.6% as compared with 16.6%). The amounts of all other elements are considerably

TABLE 3.—*Amounts of nutrients returned to the soil annually.*

Tree species	Nutrient elements, pounds per acre				
	Ca	Mg	K	P	N
Red pine	19.5	6.3	11.8	2.4	23.2
White pine*	16.4	4.4	4.9	1.4	31.2
White pine†	16.4	5.7	4.9	1.9	27.3
Hemlock	8.9	1.8	3.6	0.9	13.5
Red spruce	13.2	3.3	5.8	1.7	14.9
Balsam fir	28.8	4.1	3.1	2.3	32.1
Norway spruce	65.4	7.7	13.2	3.0	34.4
White cedar	43.3	3.0	5.0	0.8	12.1
Av. all species	26.5	4.5	6.5	1.8	23.6

*From Adirondacks.
†From Ithaca.

smaller in the case of the conifers as compared with the hardwoods.

The significance of data of the kind reported in this paper have been amply discussed by the writer (5, 6, 7), as well as by Mitchell (14, 15), Alway and Zon (2), Alway, Kittredge, and Methley (1), Broadfoot and Pierre (4), Marten and Pohlman (13), Plice (16), Jenny (12), and others. The main purpose of this paper is to place the data on record for ready reference by those who are interested.

SUMMARY AND CONCLUSIONS

A study was made of the annual leaf litter deposition from seven common conifers of the northeastern United States, and the litter samples were analyzed for calcium, magnesium, potassium, phosphorus, and nitrogen. The data seem to warrant the following conclusions:

1. The average annual litter fall (needles only) was 2,463 pounds per acre of oven-dry material.

2. The calcium content of the litter varied from 0.58% for red pine to 2.16% for white cedar. The nitrogen content varied from 0.60% for white cedar to 1.25% for balsam fir. The potassium content varied from 0.12% for balsam fir to 0.39% for Norway spruce. The magnesium content showed little variability among species, ranging from 0.14% for hemlock to 0.21% for white pine. The phosphorus content was very low ranging from 0.04% for white cedar to 0.10% for red spruce.

3. The average total amounts of nutrients returned annually to an acre of ground, expressed in pounds per acre, were as follows: calcium, 26.5; nitrogen, 23.6; potassium, 6.5; magnesium, 4.5; and phosphorus, 1.8.

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